

WHAT IS CLAIMED IS:

1. A transmission unit with failure recovery functions, comprising:

5 label table management means for managing a label table which associates incoming labels related to incoming transmission data with outgoing labels related to outgoing transmission data;

10 transmission means for controlling label-switched routing of the incoming transmission data, based on the label table;

15 path set-up means for establishing a loop-shaped protection path that includes a part or whole of transmission links of an existing working path and would allow transmission data to flow in the opposite direction to that of the working path; and

20 failure recovery means for executing a failure recovery process when a failure occurs on the working path, by changing the association between the incoming and outgoing labels stored in the label table, so as to switch the failed part of the working path to the loop-shaped protection path.

2. The transmission unit according to claim 1,
25 wherein the path set-up means establishes the loop-shaped protection path by selecting one particular node on the working path and then drawing a closed-loop path that

starts from the selected node and returns to the same selected node.

3. The transmission unit according to claim 1,
5 wherein the label table management means manages:

(a) a working-path label table, each entry of which comprises:

a working-path input parameter field storing an input interface identifier of the working path and an incoming label associated therewith, and
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a working-path output parameter field storing an output interface identifier of the working path and an outgoing label associated therewith;

(b) a protection-path label table, each entry of which comprises:
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a protection-path input parameter field storing an input interface identifier of the protection path and an incoming label associated therewith, and

a protection-path output parameter field storing an output interface identifier of the protection path and an outgoing label associated therewith; and
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(c) a detour-path label table used to define a detour path for bypassing the failed portion of the working path.

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4. The transmission unit according to claim 3, wherein:

when the transmission unit is located upstream of the failed portion of the working path, the failure recovery control means constructs the detour-path label table by combining the working-path input parameter field and the protection-path output parameter field, and performs switching from the working path to the loop-shaped protection path, based on the constructed detour-path label table; and

when the transmission unit is located downstream of the failed portion of the working path, the failure recovery control means constructs the detour-path label table by combining the working-path output parameter field and the protection-path input parameter field, and performs switching from the loop-shaped protection path to the working path, based on the constructed detour-path label table.

5. The transmission unit according to claim 1, wherein:

the transmission unit is involved in a plurality of working paths being established along a particular route;

the label table management means makes the label table include working-path identifiers each assigned to the plurality of working paths; and

the failure recovery control means associates the established protection path with one of the working-path

identifiers, whereby the protection path would be used to repair the working path having that working-path identifier.

5 6. The transmission unit according to claim 1,
wherein:

the transmission unit is involved in a plurality of working paths being established along a particular route;

10 the label table management means makes the label table include a protection-path identifier assigned to the established protection path; and

the failure recovery control means associates the protection-path identifier with one of the established working paths, whereby the protection path would be used to repair the working path associated with the protection-path identifier.

20 7. The transmission unit according to claim 1,
wherein:

the transmission unit is involved in a plurality of working paths being established along a particular route;

25 the label table management means makes the label table include priority levels each assigned to the plurality of working paths; and

the failure recovery control means uses the

established loop-shaped protection path to repair the working path having a higher priority level.

8. The transmission unit according to claim 1,
5 wherein the failure recovery control means detects a loopback point that has been produced as a result of switching from the working path to the loop-shaped protection path, and eliminates the detected loopback point, one point at a time, until a loopback-free detour
10 path is finally formed.

9. The transmission unit according to claim 1,
wherein the failure recovery control means creates a loopback-free detour path by proactively avoiding loopback
15 points that could be produced as a result of switching from the working path to the loop-shaped protection path.

10. A transmission unit with failure recovery functions which restores communication over an optical
20 network, comprising:

label table management means for managing a label table which associates incoming labels related to incoming optical transmission data with outgoing labels related to outgoing optical transmission data, the incoming and
25 outgoing labels being associated with optical wavelengths;

transmission means for controlling switching of the incoming optical transmission data, based on the label

table;

optical path set-up means for establishing a loop-shaped protection optical path that includes a part or whole of transmission links of an existing working optical path and would allow transmission data to flow in the opposite direction to that of the working optical path; and

failure recovery means for executing a failure recovery process when a failure occurs on the working optical path, by changing the association between the incoming and outgoing labels stored in the label table, so as to switch the failed part of the working optical path to the loop-shaped protection optical path.

11. A failure recovery method comprising the steps of:

(a) managing a label table which associates incoming labels related to incoming transmission data with outgoing labels related to outgoing transmission data;

(b) establishing a loop-shaped protection path that includes a part or whole of transmission links of an existing working path and would allow transmission data to flow in the opposite direction to that of the working path; and

(c) executing a failure recovery process when a failure occurs on the working path, by modifying the association between the incoming and outgoing labels

stored in the label table, so as to switch the failed part of the working path to the loop-shaped protection path.

12. The failure recovery method according to claim 11, wherein the establishing step (b) establishes the loop-shaped protection path by selecting one particular node on the working path and then drawing a closed-loop path that starts from the selected node and returns to the same selected node.

13. The failure recovery method according to claim 11, wherein the managing step (a) manages:

(a1) a working-path label table, each entry of which comprises:

a working-path input parameter field storing an input interface identifier of the working path and an incoming label associated therewith, and

a working-path output parameter field storing an output interface identifier of the working path and an outgoing label associated therewith;

(a2) a protection-path label table, each entry of which comprises:

a protection-path input parameter field storing an input interface identifier of the loop-shaped protection path and an incoming label associated therewith, and

a protection-path output parameter field storing an output interface identifier of the loop-shaped

protection path and an outgoing label associated therewith; and

(a3) a detour-path label table used to define a detour path for bypassing the failed portion of the working path.

14. The failure recovery method according to claim 13, wherein:

at a transmission unit located upstream of the failed portion of the working path, the executing step (c) constructs the detour-path label table by combining the working-path input parameter field and the protection-path output parameter field, and performs switching from the working path to the loop-shaped protection path, based on the constructed detour-path label table; and

at another transmission unit located downstream of the failed portion of the working path, the executing step (c) constructs the detour-path label table by combining the working-path output parameter field and the protection-path input parameter field, and performs switching from the loop-shaped protection path to the working path, based on the constructed detour-path label table.

15. A packet transmission unit with failure recovery functions, comprising:

label table management means for managing a label

table which associates incoming labels related to incoming packets with outgoing labels related to outgoing packets;

transmission means for controlling label-switched routing of the incoming packets, based on the label table;

5 path set-up means for establishing a loop-shaped protection path that includes a part or whole of transmission links of an existing working path and would allow packets to flow in the opposite direction to that of the working path; and

10 failure recovery means for executing a failure recovery process when a failure occurs on the working path, by changing the association between the incoming and outgoing labels stored in the label table, so as to switch the failed part of the working path to the loop-shaped
15 protection path.

16. A network system with failure recovery functions, comprising:

a plurality of transmission units, each
20 comprising:

label table management means for managing a label table which associates incoming labels related to incoming transmission data with outgoing labels related to outgoing transmission data,

25 transmission means for controlling label-switched routing of the incoming transmission data, based on the label table,

path set-up means for establishing a loop-shaped protection path that includes a part or whole of transmission links of an existing working path and would allow transmission data to flow in the opposite direction to that of the working path, and

failure recovery means for executing a failure recovery process when a failure occurs on the working path, by changing the association between the incoming and outgoing labels stored in the label table, so as to switch the failed part of the working path to the loop-shaped protection path; and

a transmission medium which interconnects the plurality of transmission units to form a network.